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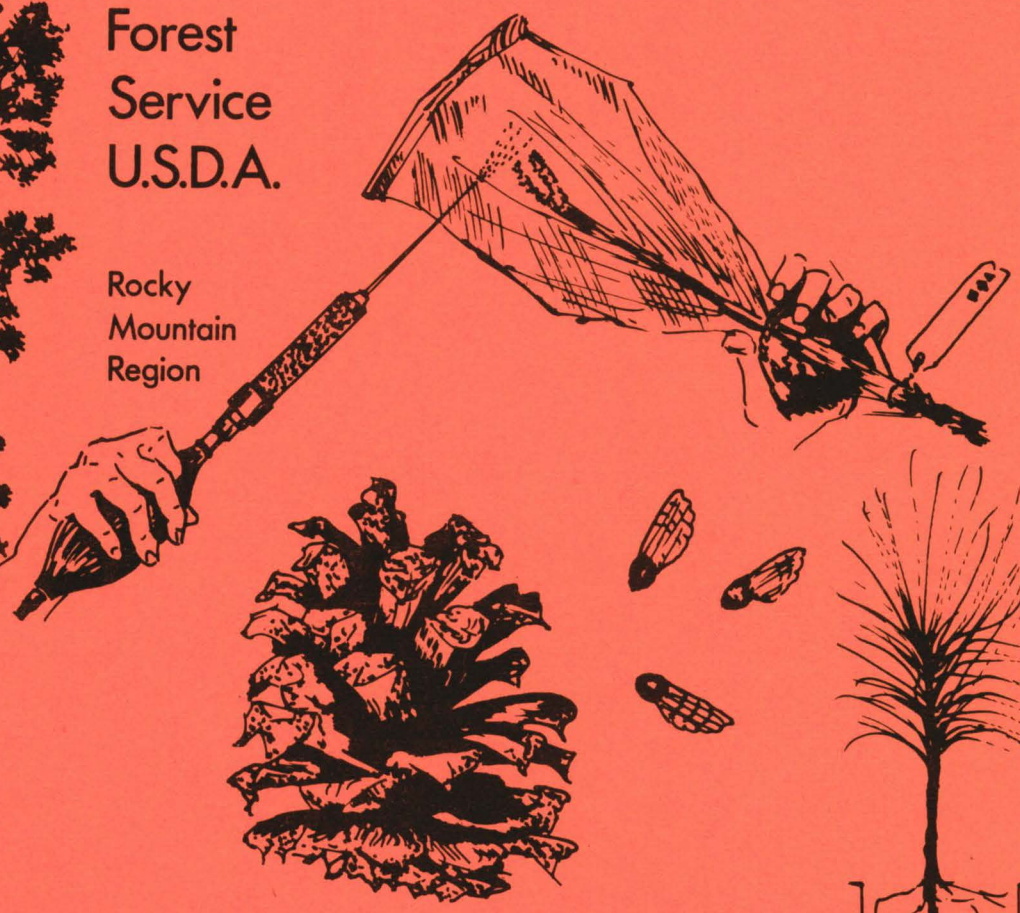
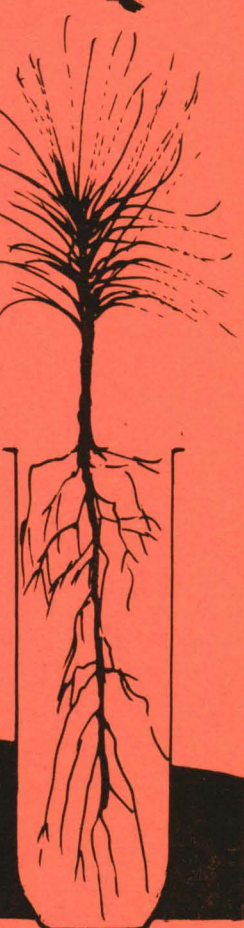
Tree Improvement Program

Forest Service U.S.D.A.

Rocky Mountain Region





TREE IMPROVEMENT PROGRAM

ROCKY MOUNTAIN REGION
USDA Forest Service

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ACKNOWLEDGEMENT

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TREE IMPROVEMENT PROGRAM

ROCKY MOUNTAIN REGION

I. Introduction

The primary mission of the Timber Management System of the U. S. Forest Service is to increase growth, utilization and utility of wood and wood products to help meet the Nation's short and long-term needs (USDA Forest Service 1976a).

Consumption of industrial wood products has been increasing steadily. Between 1942 and 1972 this increase amounted to 65 percent. Projections indicate that between 1970 and 2000 there will be increases in demand of 5 percent for saw logs, 58 percent for veneer logs and 130 percent for round pulpwood (USDA Forest Service 1973). At the same time, as demand for forest products is increasing, there is a decreasing land base on which to grow these products.

In the 1974 Recommended Renewable Resources Program, the Chief recommended Goal C for timber; namely, to increase timber supplies and quality in an environmentally sound manner to the point where benefits are commensurate with costs (USDA Forest Service 1976a). Among several alternatives available for increasing timber supplies on a reduced land base is the utilization of sound genetic principles in all phases of forest regeneration. In general, limited genetic improvement may be expected in stands that are naturally regenerated (Zobel 1977). In contrast, genetic improvement achieved through artificial regeneration may be considerable. Increases of 10-15 percent in volume production have been achieved in other regions through use of genetically improved planting stock. Similar gains are possible in Region 2.

Congress, through the National Forest Management Act of 1976, has authorized a $200 million annual appropriation and directed an expedited schedule for reforestation and timber stand improvement in accordance with timber management plans. Resulting intensified timber management can be used to justify increases in timber harvests (USDA Forest Service 1976b).

If Region 2 is to contribute its full share toward meeting the National goal of increased timber supply on a reduced land base, then the Region must utilize more intensified timber management practices, expand its artificial reforestation program and tree improvement must be an integral part of its timber management program.

II. Objectives

The objectives of the Region 2 Tree Improvement Program are:

A. To provide a continuing supply of improved seed to meet annual artificial regeneration needs for all species. Use of improved

seed will result in:

1. Increased survival resulting from use of planting stock produced from local seed.

2. Increased yields of usable fiber (sawtimber, roundwood poles, posts, etc.).

3. Improved tree quality.

4. Reduced susceptibility to diseases, insects and other pests.

B. To incorporate genetic principles in the culture and management of trees for forest products and other uses.

III. Current Situation

A. Commercial and Regulated Forest Land

As of January 1, 1977, there were nearly 10.4 million acres of commercial Forest land (CFL) on the National Forests in Region 2 (Table 1). Included in this total are 3,106 M acres (30%) in the spruce/fir type, 2,128 M acres (21%) in lodgepole pine, 2,086 M acres (20%) in ponderosa pine, 936 M acres (9%) in Douglas-fir/white fir, 92 M acres (1%) in white pines, 5 M acres (less than 0.1%) in other softwoods and 2,041 M acres (20%) in aspen/other hardwoods.

Approximately 98% (7.192 M acres) of the regulated CFL is in the spruce/fir, lodgepole pine, ponderosa pine and Douglas-fir/white fir site types. Included in this total are 2,840 M acres (40%) in spruce/fir, 1,958 M acres (27%) in lodgepole pine, 1,745 M acres (24%) in ponderosa pine and 648 M acres (9%) in Douglas-fir/white fir.

B. Artificial Regeneration

Between 1968 and 1977, approximately 16.5 M acres/year have been regenerated naturally and artificially. Of this total, approximately 9.1 M acres (55%) were regenerated naturally, 6.0 M acres (37%) were planted and 1.4 M acres (8%) were direct seeded. During this period, the average annual number of acres regenerated naturally and artifically increased from 15.8 M between 1968-1972 to 17.1 M between 1973-1977. There was a substantial increase in the average annual number of acres regenerated naturally from 7.7 M acres (49% of total acres regenerated) between 1968-1972 to 10.4 M acres (61% of total) between 1973-1977, a slight increase in number of acres direct seeded annually from 1.1 M acres (7% of total) between 1968-1972 to 1.6 M acres (9% of total) between 1973-1977, and a substantial decrease in the number of acres planted annually from 7.0 M acres (44% of total) between 1968-1972 to 5.1 M acres (30% of total) between 1973-1977. During the same period of time, the number of trees planted per acre has also decreased from more than 500 per acre between 1968 and 1970 to less

Table 1 - Area of Commercial Forest Land by Forest Type and Site Class
Region 2 National Forests
(Inventory January 1, 1977)

Forest Type

Site Class $ft^3/a/yr.$		Spruce/Fir	Lodgepole	Ponderosa	Douglas Fir/ White Fir	White Pine	Other Softwoods	Aspen/ Others	Total All Types
120+	M Acres	2.3							2.3
	% CFL	0.1							
85-119	M Acres	249.5	14.3	2.9	7.2			51.8	325.7
	% CFL	8.0	0.7	0.1	0.8			2.5	3.1
50-84	M Acres	1500.6	192.8	205.3	514.5	7.6		605.5	3026.3
	% CFL	48.3	9.1	9.8	55.0	8.3		29.7	29.1
20-49	M Acres	1353.8	1920.4	1877.6	413.9	84.4	4.9	1383.3	7038.3
	% CFL	43.6	90.3	90.0	44.2	91.7	100.0	67.8	67.7
Total	M Acres	3106.2	2127.5	2085.8	935.6	92.0	4.9	2040.6	10,392.6
	% CFL	29.9	20.5	20.1	9.0	0.9		19.6	

than 400 between 1974 and 1977. At the same time, planting costs per acre have steadily increased from $177/acre in 1968 to $285/acre in 1977.

Yearly projected planting needs, including net backlog and current acres between 1978 and 1985, amount to approximately 17.5 M acres, and if the backlog not feasible for planting before FY 1985 is scheduled for planting after 1985, then the projected yearly planting needs will remain at about 17.5 M acres through 1995. However, if the timber sales program should increase in the future and if more intensified timber management practices are employed, then conceivably the yearly planting needs would increase. And if more intensified timber management practices are implemented, then a greater percentage of acres to be regenerated yearly should be planted, with an ever improving quality of planting stock.

Between 1970 and 1977, annual shipments to the National Forests in the Region included approximately 1,143 M Engelmann spruce (44% of total), 726 M lodgepole pine (28%), 715 M ponderosa pine (27%) and 35 M Douglas Fir (1%). Projected yearly planting needs for 1978 through 1985 include 3,931 M Engelmann spruce (56% of total), 1,087 M lodgepole pine (16%) and 1,976 M ponderosa pine (28%).

With increasing emphasis on natural regeneration of Engelmann spruce, the proportion of Engelmann spruce planted to total acres planted will probably decrease while the proportion of pine planted will increase. With increases in timber sales and implementation of intensified timber management practices such as accelerated reforestation, the current planting needs for the pines will probably increase.

IV. Species Priorities

Species priorities in the Region 2 Tree Improvement Program, in descending order, are:

A. Engelmann spruce

B. Ponderosa pine

C. Lodgepole

D. Douglas-fir

These priorities are based upon current value of species for timber and other uses, acres in commercial Forest land and size of planting program until backlog is completed. However, if more intensified timber management practices are utilized in the future, then individual species priorities may change.

On an individual Forest basis, the species priorities will not necessarily be the same as the Region's and in most instances only one or perhaps two species will be involved in all tree improvement intensity levels. In a few instances, only limited tree improvement activities will be

utilized, at least for the immediate future.

V. Program Intensity Levels

There are five tree improvement program intensity levels specified in the Forest Service Manual (FSM 2475.3) and they are ranked according to increasing complexity based upon input and potential genetic gain that can be attained. These levels include 1) seed collection zones, 2) seed collection stands, 3) seed production areas, 4) seed orchards and 5) selective breeding.

A. Level 1 - Seed Collection Zones

All states in Region 2 have been zoned for tree and shrub seed collection (Cunningham 1975, Seed Collection Zone Maps, R2-2470-15a, b and c). These zones were developed by first subdividing each state into regions based on major land resource areas developed by the Soil Conservation Service (Austin 1972) utilizing soil, climate and land use data. The major land resource areas were subdivided into seed collection zones by superimposing climatic data, including mean January temperature and normal annual precipitation (U.S. Dept. of Commerce 1968), on the major land resource use areas. Seed zone boundaries were adjusted in some instances to confirm to recognizable local land features such as lakes, rivers and highways. Development of these seed collection zones was a cooperative effort involving Timber Management, State and Private Forestry, Research and State agencies. Seed collection zone boundaries will be evaluated and adjusted, if necessary, when research and evaluation plantation data becomes available.

A long-term record keeping system will be developed and maintained by the Regional Geneticist to insure maintenance of identity of reproductive material through all stages of collection, processing, storage, nursery production and distribution including final use in reforestation and tree improvement projects.

Tree Seed - Currently, tree seed is collected from National Forests in Region 2 from designated seed collection zones and, whenever possible, within 500 feet elevation of future planting sites within the designated collection zones. Identity of the seed is carefully maintained through coding by species, seed collection zone, seed source, elevation, Forest, District and year of collection. Resulting stock is planted back within the same seed collection zone from which the seed was collected. Seed should be collected within seed collection zones from a minimum of 20 individual trees and/or more than one squirrel cache to ensure a broad genetic base. Seed or seedlings will not be exchanged between zones without the Regional Forester's approval.

Shrub Seed - Very little is known about genetic variation and improvement methods and techniques for shrub species utilized by wildlife. Until such time that more specific information is available on shrub species we should collect seed of local origins from natural communities utilizing available tree and shrub seed

collection zone information (Cunningham 1975, Seed Collection Zone Maps, R2-2470-15a, b and c).

B. Level 2 - Seed Collection Stands

Seed collection stands are groups of individual trees or stands within seed collection zones that exhibit above average performance and are managed for seed production. They should be located on sites and at elevations representative of future planting areas. Seed collection stands should be designated for repeated seed collection, marked and reserved from timber harvest. However, to ensure that seed is collected only from good phenotypes, inferior phenotypes should be removed (rogued) within groups of individuals and within stands. After roguing, these stands will be considered as seed production areas (SPA).

Seed collection stands and seed production areas will be the primary sources of seed for Region 2 until seed is available from seed orchards and/or tested selected individuals. Seed from these later sources probably will not be available before 2010.

Guidelines for the selection and maintenance of selection collection stands will be developed by the Regional Geneticist. The Regional Geneticist will certify seed collection stands for inclusion in the Region's seed collection program.

C. Level 3 - Seed Production Areas

Seed production areas are usually established in tested and proven natural stands. Undesirable individuals are removed and the best individuals treated to promote early and abundant seed production. These stands are usually protected against serious damaging pests.

Currently there are two established seed production areas, both in ponderosa pine, in the Region; one on the Black Hills National Forest and one on the San Juan National Forest. However, quality of seed produced from these stands has not been evaluated and genetic value of these stands has not been established. As a selection and testing program is implemented in the Region, seed from individuals in seed production areas will be tested and promising progenies will be retained for future breeding work. The Regional Geneticist, in cooperation with Forest personnel, will be responsible for establishment and maintenance of seed production areas.

D. Level 4 - Seed Orchards

Seed orchards are plantations of clones (a clone is a group of genetically identical individuals produced asexually by grafting or rooting of cuttings from a single individual) and/or seedlings from selected trees managed for early and abundant seed production.

The Regional Geneticist, in cooperation with other Federal, State and private organizations, will establish the boundaries of breeding zones; geographic areas based on anticipated adaptability of an improved population of trees for each of the species included in the tree improvement program. A breeding zone may be larger than a seed collection zone.

Environmental variables including climate, soils, provenance research and evaluation plantation results can be utilized in determining breeding zones. The Regional Geneticist, in cooperation with other agencies, will determine the best locations for the Region's seed orchards. Cooperative efforts to determine breeding zone boundaries and seed orchard location will begin in 1979.

E. Level 5 - Selective Breeding

Selective breeding, which involves production of seed of known parentage to provide improved materials for advanced-generation seed orchards, will become a part of the Region's tree improveemnt program following establishment of first generation orchards and evaluation of individuals in these orchards.

Because greatest overall gain will be achieved on the most productive sites, seed orchards will be established only for those areas with sufficient acreage of highly productive forest land to economically justify their establishment and management. Planting stock produced from seed orchard seed will be used only on the most productive sites (productivity 50 plus).

VI. Individual Tree Selection

A. Natural Regeneration

In stands to be naturally regenerated all silviculturally undesirable trees should be removed during precommercial thinning. Silviculturally desirable trees should be marked as parent seed trees and retained until final harvest cuts. The Regional Geneticist, in cooperation with Forest personnel, will develop and incorporate selection criteria for leave trees into Region 2 marking guidelines.

B. Parent Tree Selection and Progeny Testing

Selection of individual parent trees in natural stands and testing of their progeny will be the first major steps in the development of an intensive tree improvement program in the Region.

Because high intensity selection programs have rarely paid off, a relatively low intensity selection program will be used to identify and progeny test a large number (200-300) of trees per breeding zone.

Parent tree selection will be started in the Region in 1979. Initial parent tree selections will be made on the following Forests:

Species	Forest
Engelmann spruce	Rio Grande
Ponderosa pine	San Juan, Grand Mesa-Uncompahgre and Gunnison
Lodgepole pine	Medicine Bow, Arapaho-Roosevelt, Routt

The Regional Geneticist will establish criteria and develop guidelines for locating, selecting and marking of parent trees and procedures for progeny testing of parent trees. Forest personnel will locate and nominate potential parent trees for testing. The Regional Geneticist will certify nominated trees to be included in the Region's tree improvement program.

VII. Traits To Be Improved

The four species included in the Regional tree improvement program are all included in the State of Colorado tree improvement program (Colorado State Forest Service 1977). Consequently, traits to be improved in the Regional program will be essentially the same as those listed in the state plan. Traits to be improved include:

Engelmann spruce	Ponderosa pine	Lodgepole pine	Douglas-fir
Survival	Survival	Survival	Survival
Growth rate	Growth rate	Growth rate	Growth rate
Form	Form	Form	Form
	Pest resistance	Pest resistance	Pest resistance

VIII. Gene Pool Conservation

The basis of tree improvement is genetic diversity and the increasing demand for forest and forest related products may lead to indiscriminant mixing, impoverishment or elimination of natural gene pools. Such changes in gene pools of indigenous forest tree species are irreversible and concerted efforts must be made to conserve natural gene pools of these species.

Forest Service policy regarding gene pool conservation is currently being developed. This policy will assure conservation of genetic diversity of forest vegetation on National Forests. The Forest Service will also encourage and cooperate with other Federal, State, private and international organizations in gene pool conservation efforts, especially on extensive forest acreages where gene pool conservation may not otherwise occur.

Gene pool conservation management units may add to, but will be distinct from, gene banks of tree improvement programs.

IX. Personnel and Responsibilities

A. Regional Geneticist

The Regional Geneticist, with the assistance of Regional and National Forest Timber Management Staff and the State and Private Forestry Geneticist, will develop and implement a Regional Tree Improvement Program for the National Forests in the Rocky Mountain Region. He will also provide training, technical expertise and guidance in tree improvement to the National Forests in the Region.

The Regional Geneticist, in cooperation with the State and Private Forestry Geneticist, will be responsible for coordinating the Region's tree improvement program with the tree improvement programs of other Federal, State and private organizations within the states in the Region.

The Regional Geneticist will also be responsible for developing and maintaining a Regional Tree Improvement Handbook. The Tree Improvement Handbook will provide specific direction and technical guidelines needed to meet the Regional tree improvement objectives.

The Regional Geneticist will develop procedures for maintaining long-term (minimum of one rotation) record keeping systems to insure maintenance of identity of tree seed and other forest reproductive material through all stages of collection, processing, storage, nursery production and distribution including final use and tree improvement projects. (FSM 2475.03,8)

B. Forest Supervisors

Implement the Regional Tree Improvement Program and assist in development of individual Forest tree improvement plans by designating an individual responsible for planning and coordinating tree improvement activities on the Forests; and by cooperating with adjacent Forests and other Federal, State and private agencies in cooperative tree improvement projects.

C. District Rangers

District Rangers are responsible for maintaining a 10-year seed supply for each species involved in reforestation within each seed collection zone of their district (FSM 2474.2,1).

D. Nurseryman at the Mt. Sopris and Bessey Nurseries

1. Store genetically improved seed.
2. Produce seedling and clonal stock for progeny testing, seed orchards and breeding material.
3. Produce genetically improved planting stock for the National Forests.
4. Produce genetically improved planting stock for other Federal, State and private agencies under cooperative agreements.

5. Carry out assigned administrative studies in tree improvement.

E. Personnel Need - Tree Improvement Technician

There is a need for a tree improvement technician in the Region if the tree improvement program is to be fully implemented. The individual in this position will assist National Forest personnel in selection, testing and propagation of materials included in the Regional Tree Improvement Program. This individual will also be responsible for implementation of administrative studies in tree improvement and could be shared with the Mt. Sopris Nursery as their greenhouse technician.

X. Forest Plan

Individual Forests will develop specific plans for tree improvement activities based on the general direction provided in the Regional Tree Improvement Program. Forest plans should include detailed schedules of activities and target dates. Requests for funding for tree improvement activities should be included in the Forest program budget process.

The Tree Improvement section of the Forest Plan will be prepared in consultation with the Regional Geneticist.

XI. Cooperation

In order to maximize the benefits of tree improvement, the National Forest program will be coordinated with State and Private Forestry tree improvement programs, research, other Regions, other Federal agencies, universities, and private organizations in developing and implementing its tree improvement program. The Region will actively participate in cooperative tree improvement organizations such as the Rocky Mountain Forest Genetics Committee, Western Forest Genetics Association and the Great Plains Agricultural Council, GP-13 Technical Committee ("Improved Trees for the Great Plains").

XII. Regional Tree Improvement Plan Review

This plan should be reviewed, updated and revised, if necessary, three years after approval of the plan. Thereafter, the plan should be reviewed, updated and revised, if needed, every five years. However, flexibility should be maintained in the tree improvement program at all times.

XIII. Funding

Requests for funding for tree improvement activities should be handled through the normal budgetary process.

XIV. Region 2 Tree Improvement Action Plan Summary - 1979-1981

A. Tree Improvement Plan and Handbook

1.	Provide tree improvement orientation to Forest personnel - TM workshop.	2/79
2.	Prepare tree improvement plan.	7/1/79
3.	Develop tree improvement handbook - begin.	7/1/79

B. Quality Seed Collection

1.	Seed collection stand criteria.	7/1/79
2.	Reforestation workshop (Rio Grande & San Juan National Forests)	3/15/79
3.	Seed collection workshop.	7/79
4.	Select seed collection stands.	1979-81

C. Parent Tree Selection

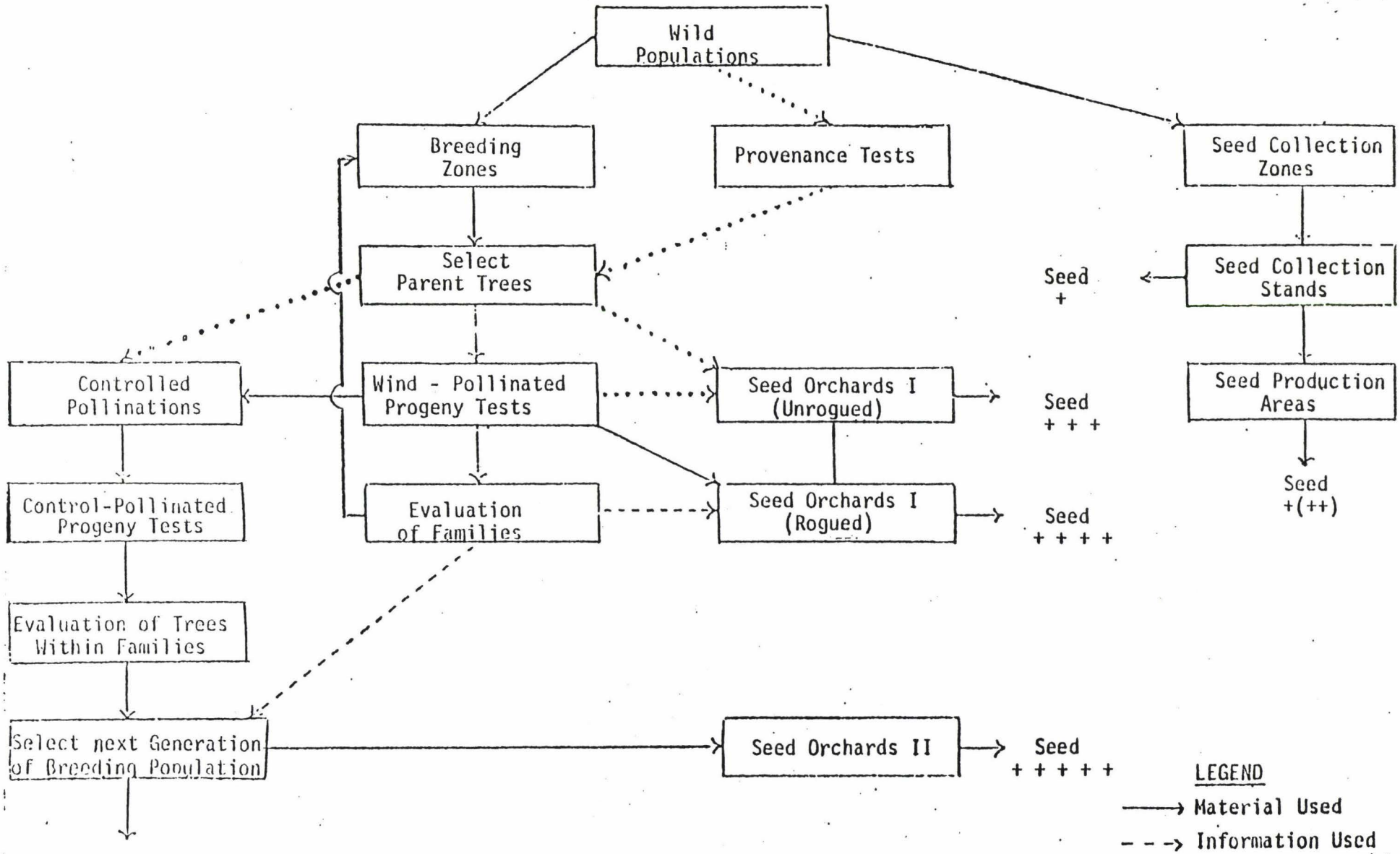
1.	Parent tree selection criteria.	7/1/79
2.	Select parent trees for progeny testing.	1979-81

D. Personnel

1.	Employ tree improvement technician.	10/1/79

XV. Flow Chart - Region 2 Tree Improvement Program

(Figure 1)



NOTE: Relative genetic improvement varies from slight (+) to most (+ + + + +)

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